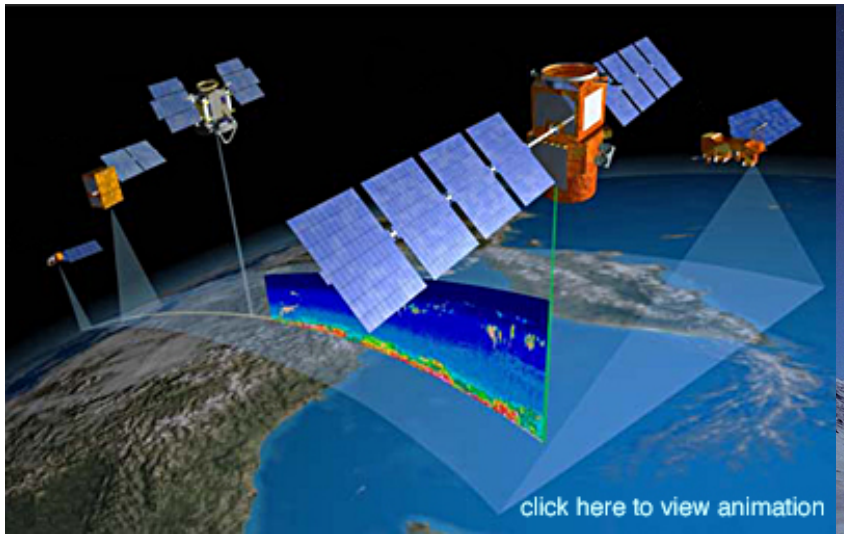
Remote sensing and numerical modelling of the atmosphere

— Student restitution 2010/07/07 —



Aims and Measurement Principle – Lidar System

Objective of Active Remote Sensing is to obtain information on the state of the atmosphere (composition, temperature, wind, etc)

Lidar uses the electromagnetic wave scattering characteristics of different particles

SIRTA Lidar uses light of 532nm and 1064nm wavelength

Time delays induced by the difference in distance travelled by the waves can be used to identify particle altitude

Profile

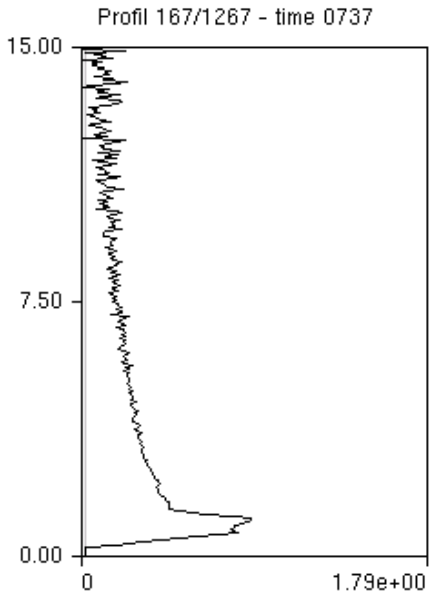
Axes: altitude & number of photons

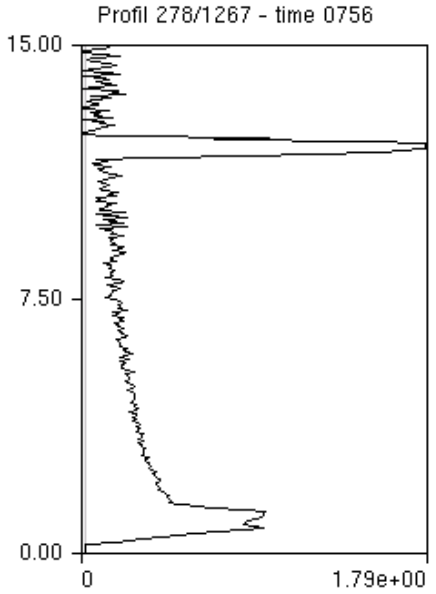
Blind range of altitude: due to limited field of telescope

Pressure is linked to molecules

Boundary layer: aerosols & dust

Cloud: the efficiency of the backscattering is higher

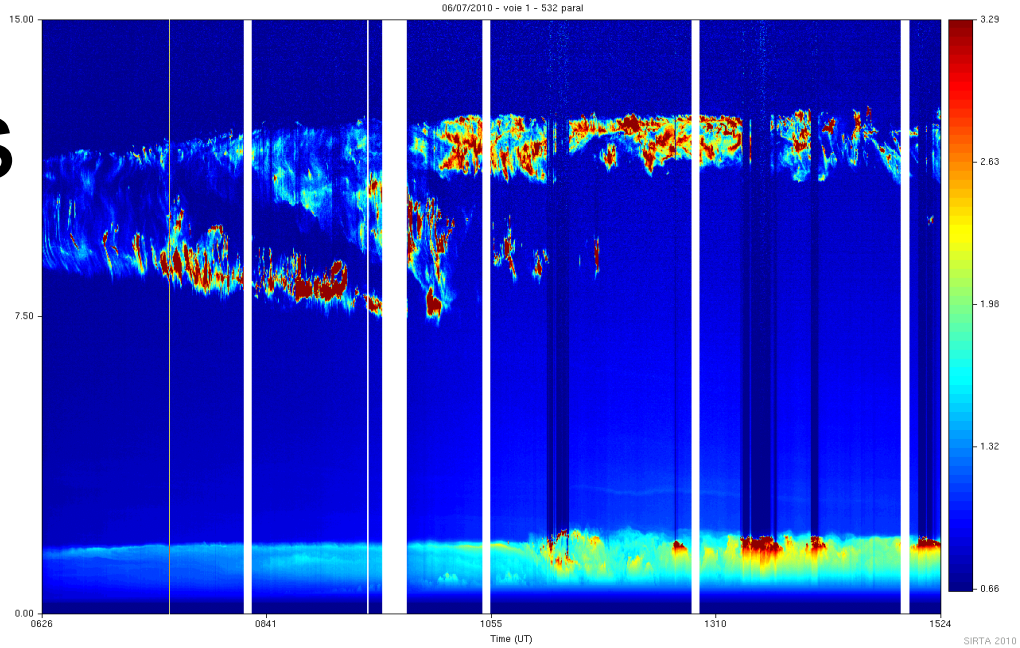


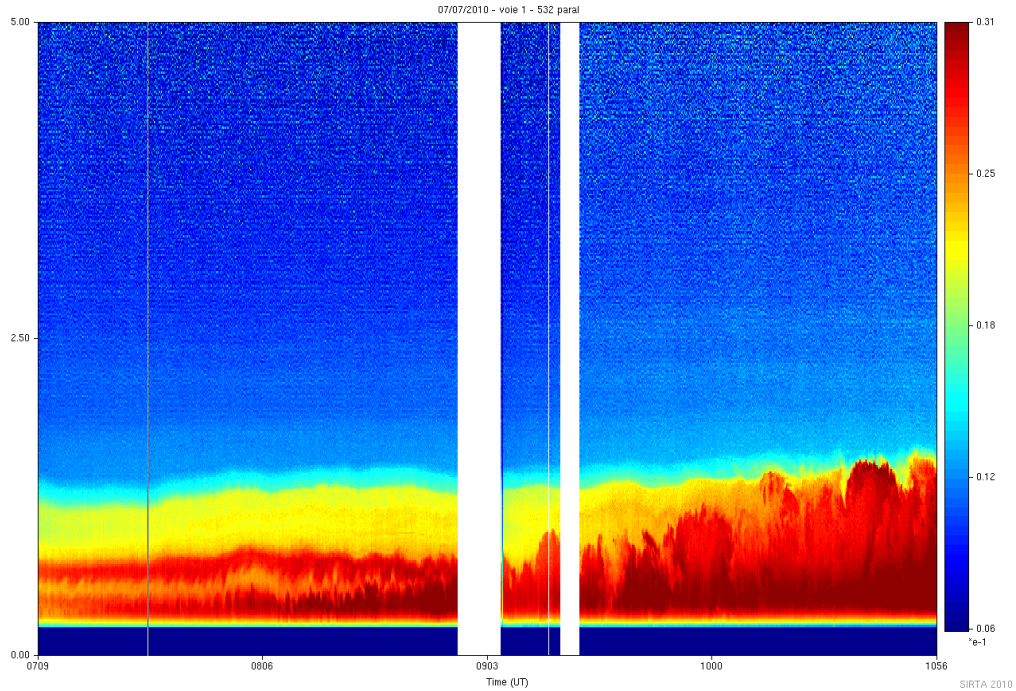


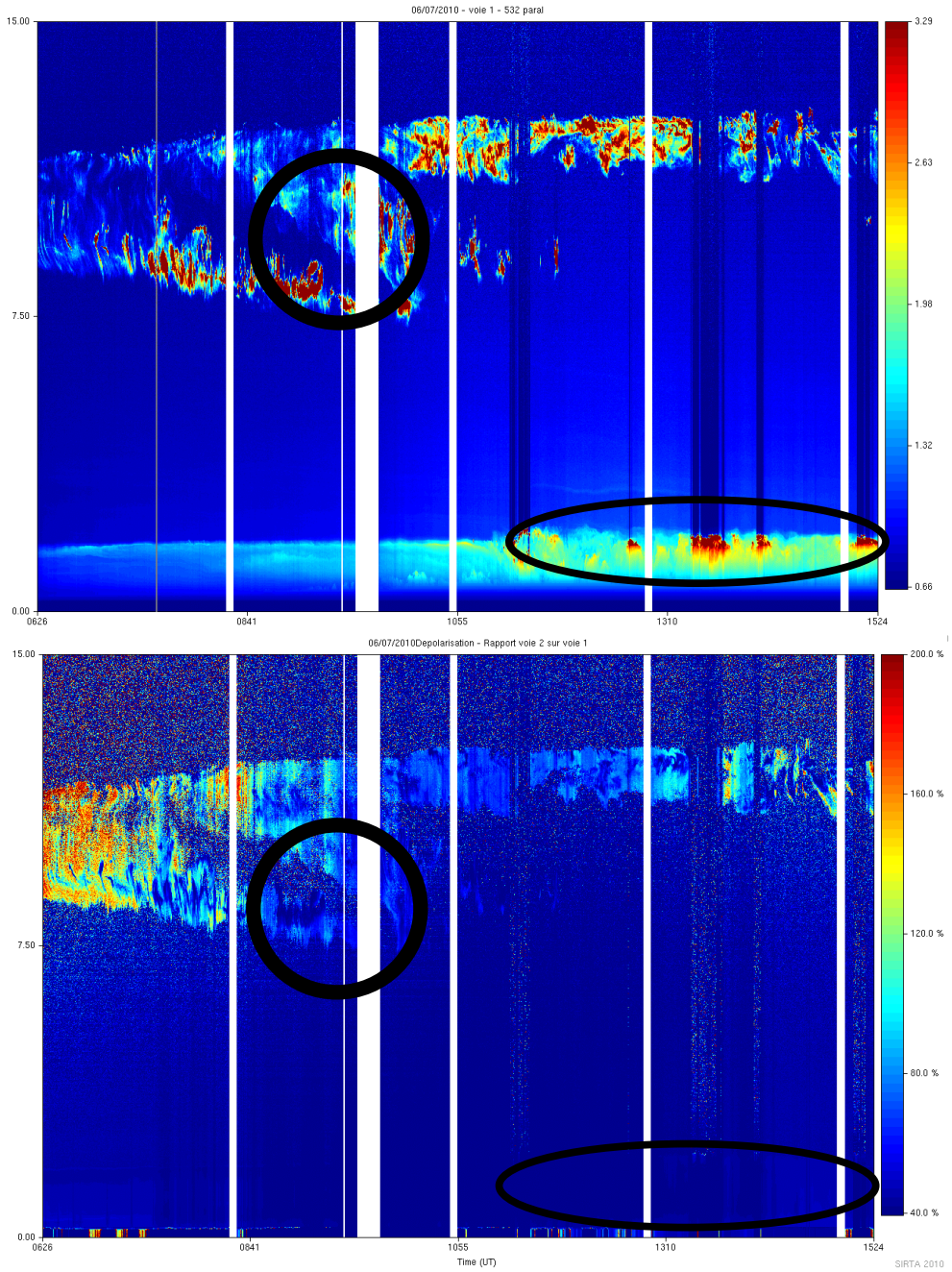
Cross Sections

- Time (TU) Vs. Altitude (km)
  - Range
- Red Vs. Blue
- White bars

- High Altitudes
  - Clouds (2 layers)
    - Intense
    - smooth
- Low Altitude
  - Aerosols (yellow)
  - Convection (red)







Standard Cross-Section

- locates aerosol/clouds in the sky

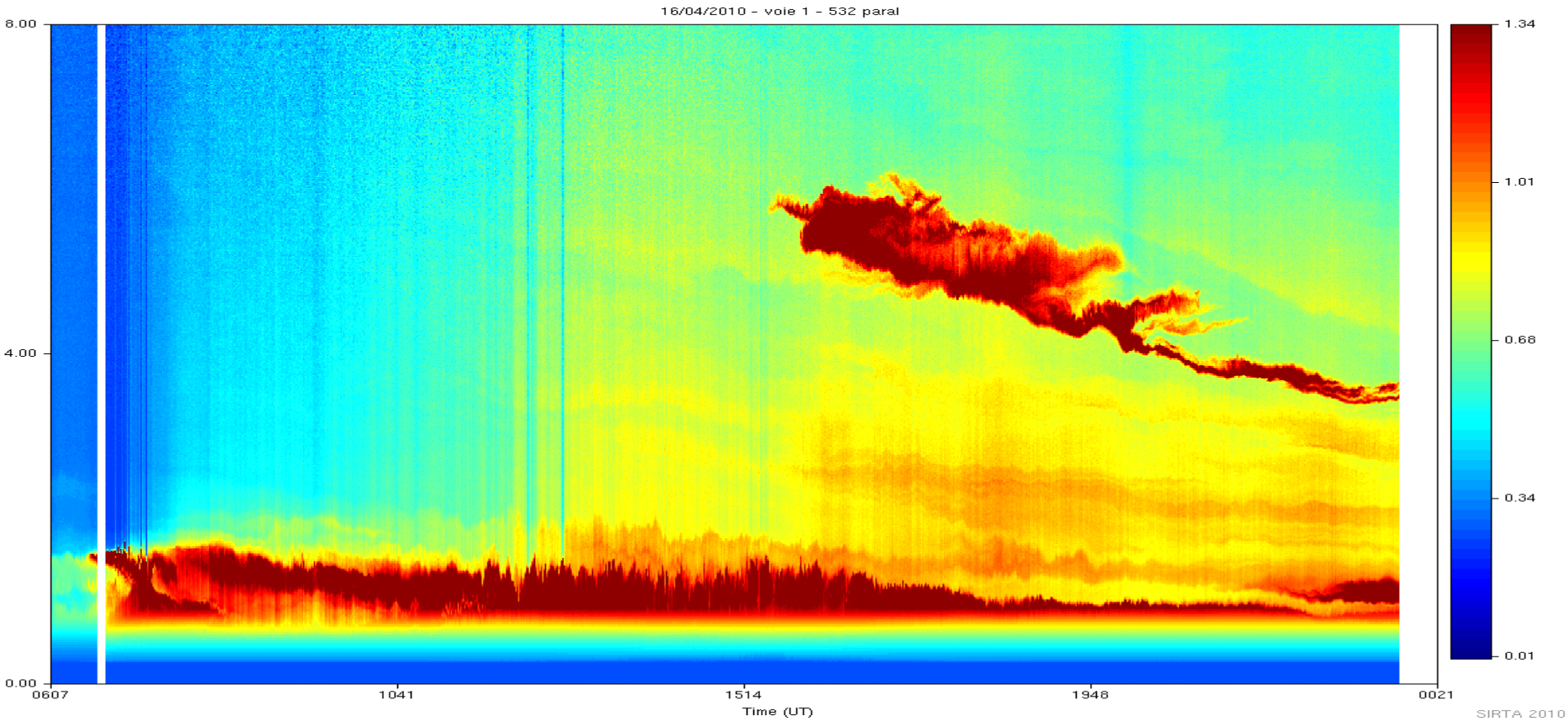
- does not show the difference between clouds

<u>Depolarization Cross-Section</u>

- gives information about kind of aerosol

- highlighted clouds might consist of liquid water and not of ice crystals

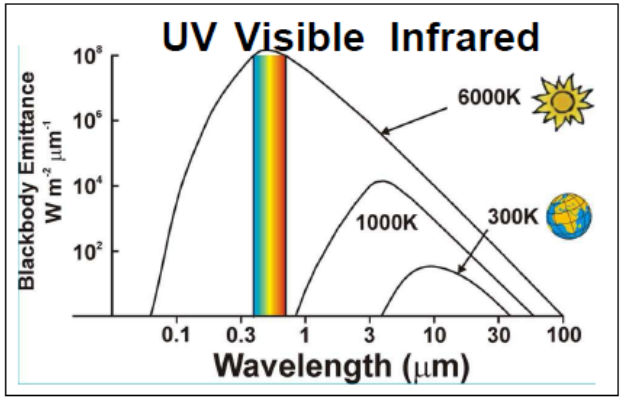
- percentage displays magnitude of directional change of the Electric field

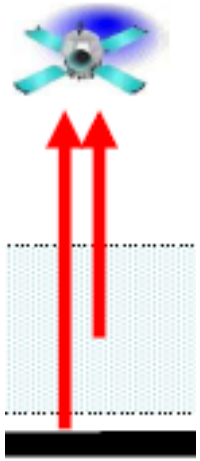


- Highest red plume shows the upper cloud of volcano particles
- During the day we see the arrival of the volcano aerosols and particles. At the end of the day, these enter the boundary layer.
- With this particular example you can see how a particular pollution affects the atmosphere

-- *Student restitution* --

Objective:
Assess concentrations of species (CO_2, CO, H_2O, Nox) in the atmosphere
Passive observations (measure of the spectrum of Earth natural radiations in the infrared that depends on the surface temperature)

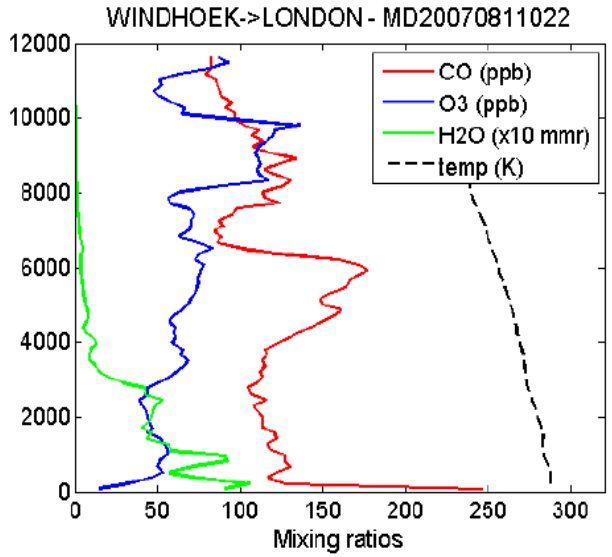




Infrared radiations interact with the chemicals in the atmosphere.
Satellites measure the resulting radiations.

Methodology

State of the atmosphere from In situ observations (aircraft)



Observation in space in the infrared?

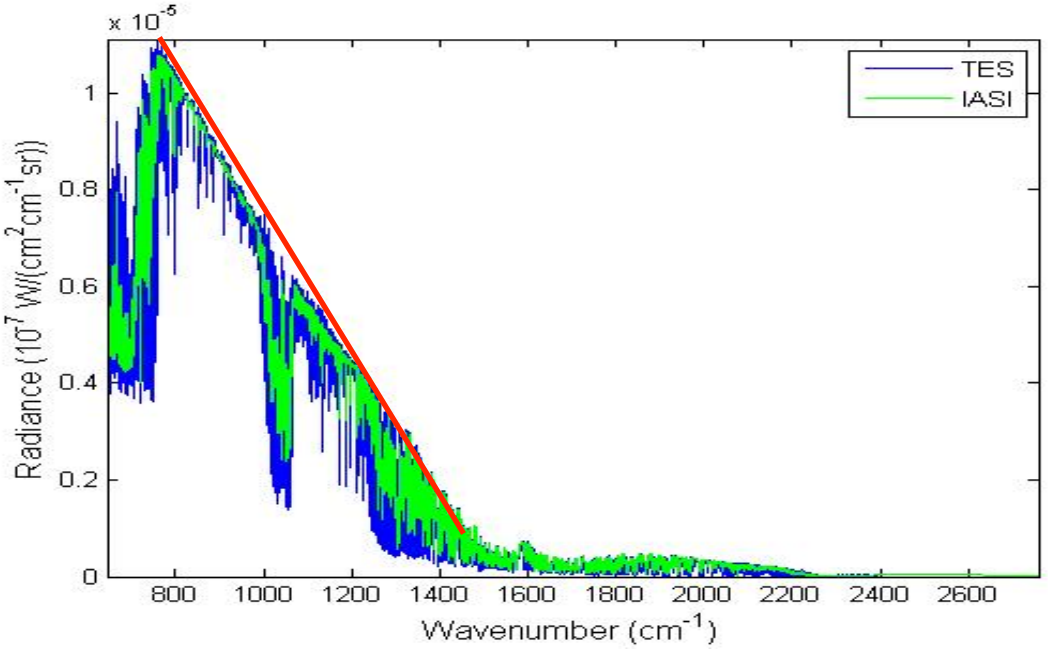
STEP 1 : Forward model simulation = radiative transfer

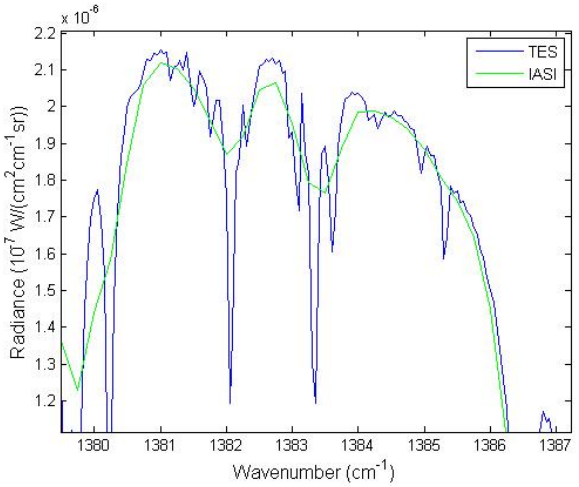
From this observation, what may be retrieved for CO mixing ratio?

STEP 2 : Inverse model simulation

Work on data series measured by two satellites (IASI, TES)
IASI : developed by CNES and EUMETSAT, IASI was built by Thales Alenia Space.

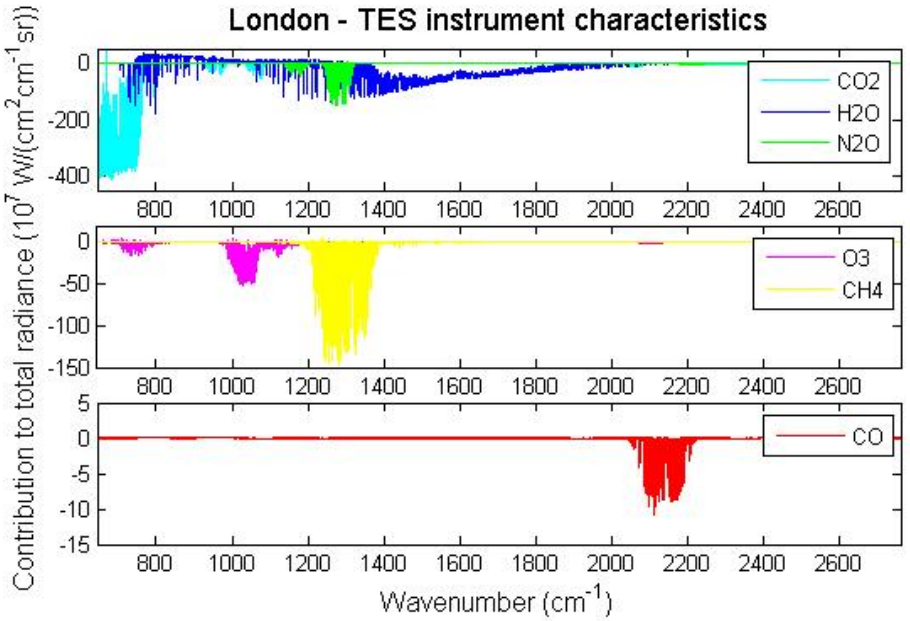
Results of the Observing System Simulation Experiment Results (1/3)

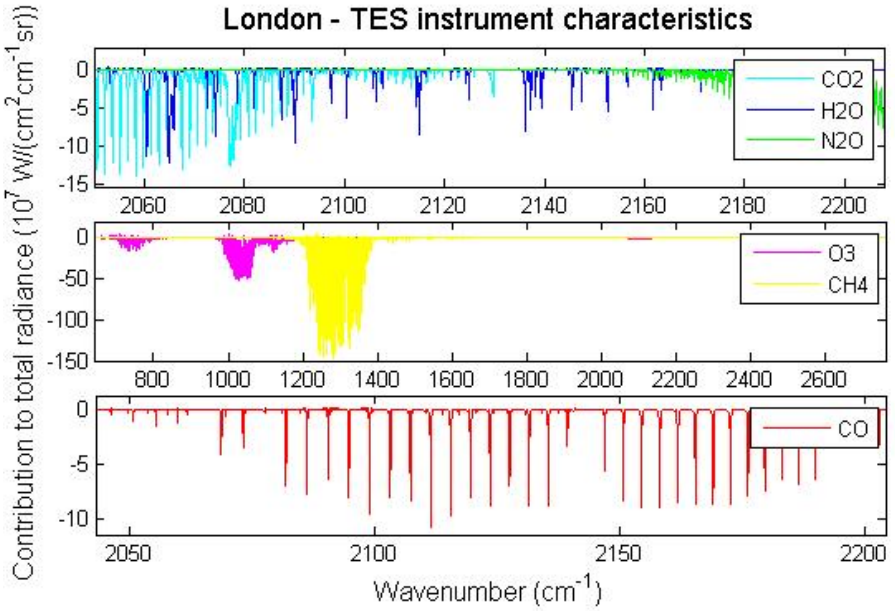




- *TES-Instrument has a finer spectral resolution*
- *Part of the radiance is absorbed by molecules in the atmosphere*

Results of the Observing System Simulation Experiment Results (2/3)

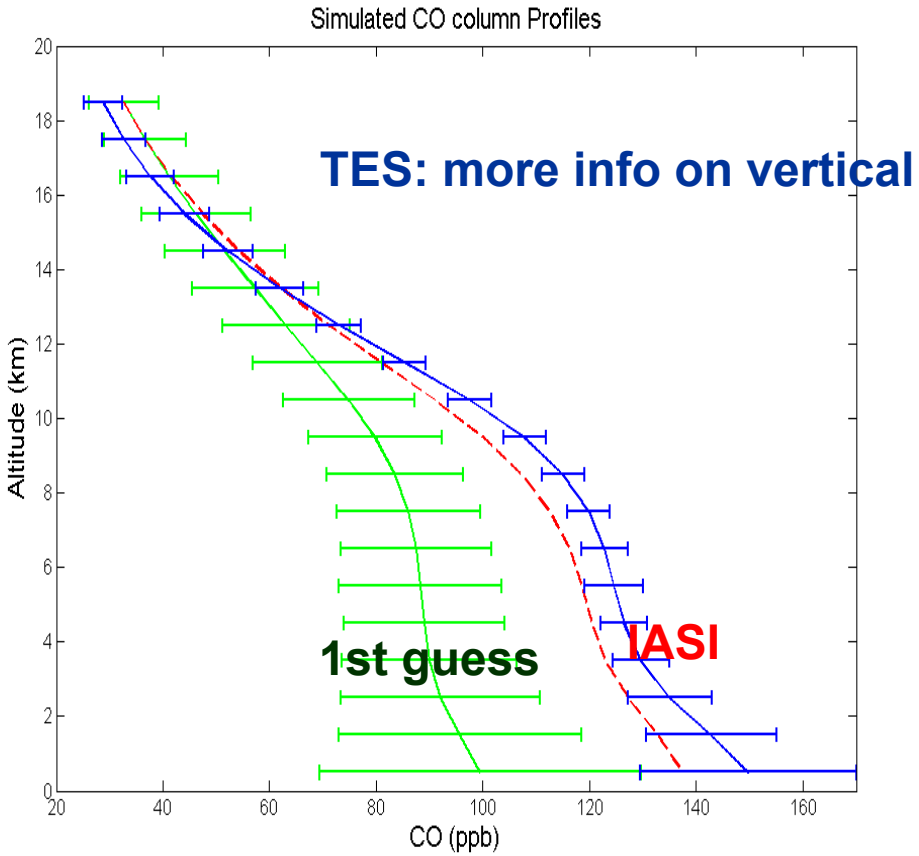




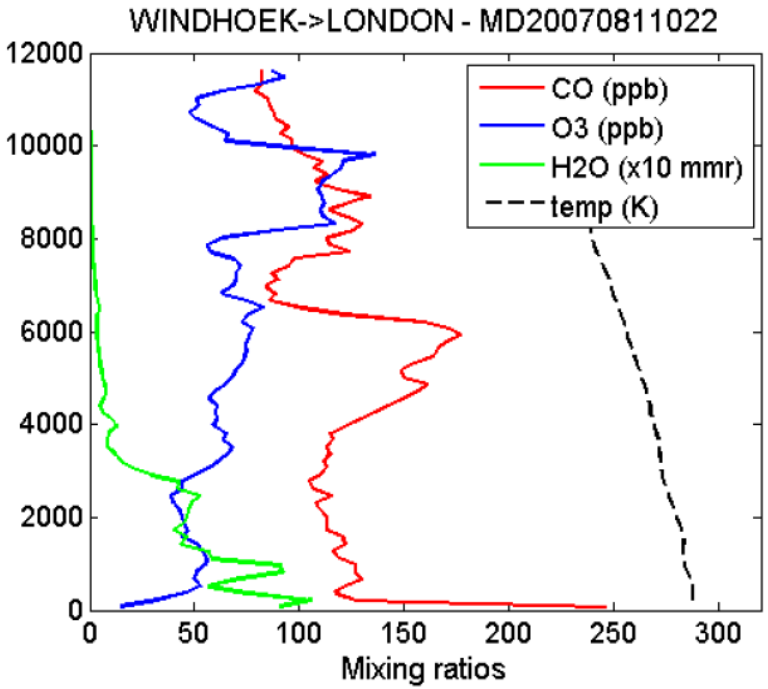
- *The various molecules absorb at certain wavelengths*
- *Overlap makes distinction between different molecules complicated (example CO → N_2O and H_2O)*
- *Solution: Retrieve N_2O and H_2O together with CO (inverse model simulation)*

Results of the Observing System Simulation Experiment Results (3/3)

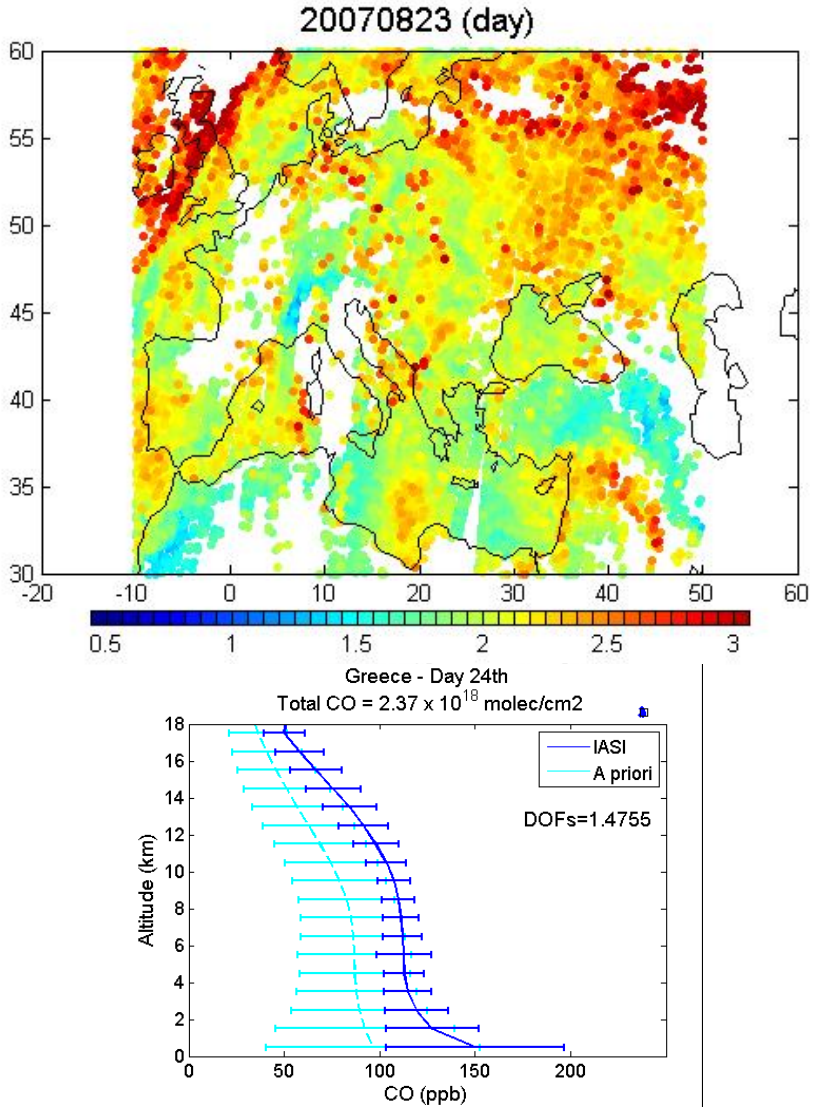
Retrieval results:

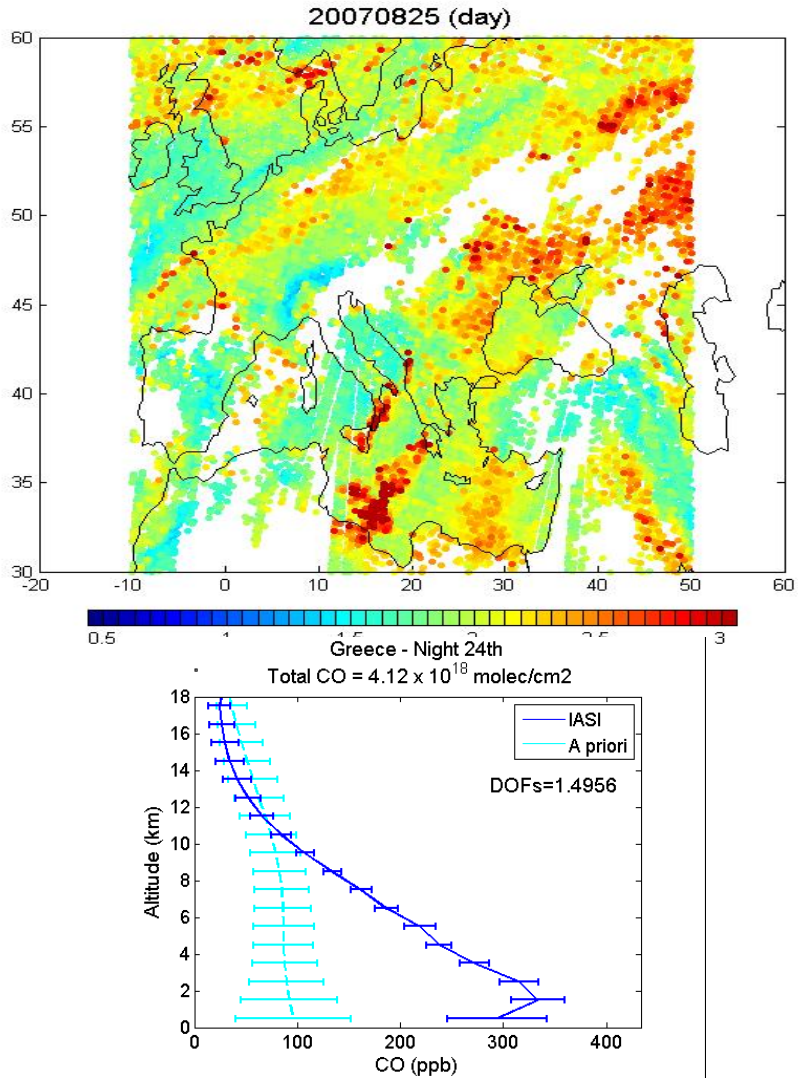


What we wanted:



From simulations to reality: IASI/METOP CO retrievals





Conclusions

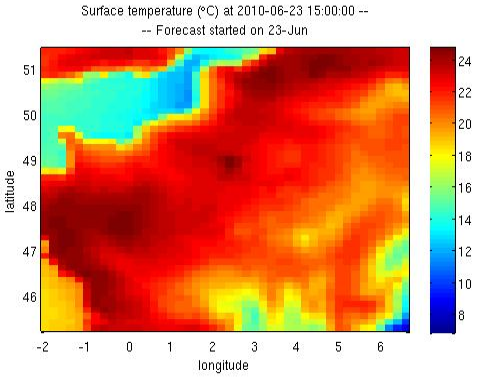
- Data-Usefulness depends on satellite instruments
- Vertical resolution is at the moment not very accurate
- Nevertheless, data can be used for various applications, e.g.:
    - air quality
    - transport of emissions (fires, volcanoes, etc)
    - greenhouse gases

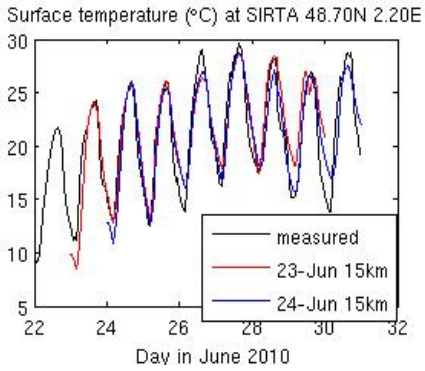
Business applications:

- data service
- Satellite/instrument application

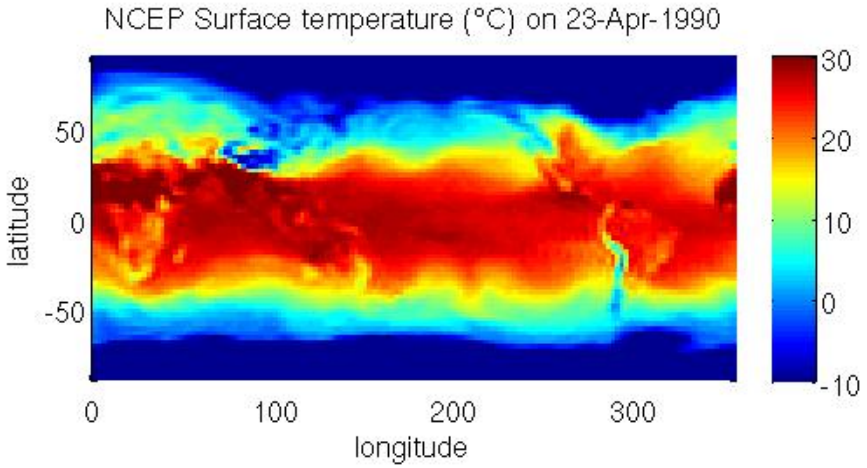
Numerical modelling of the atmosphere

- Weather Forecast models





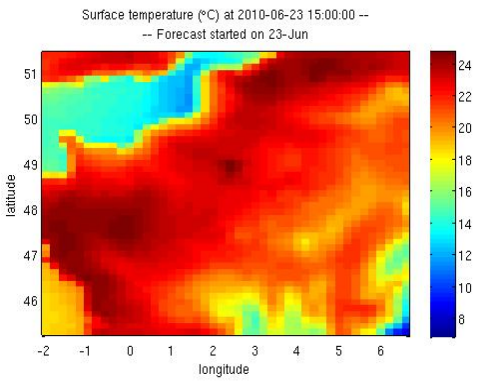
- Climate models



The impact of initial conditions to the model outputs

- The initial conditions have significant impact on the results of the weather models, but not on the climate models.

23.06.2010



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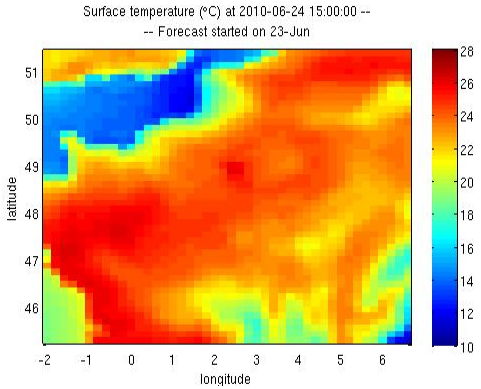

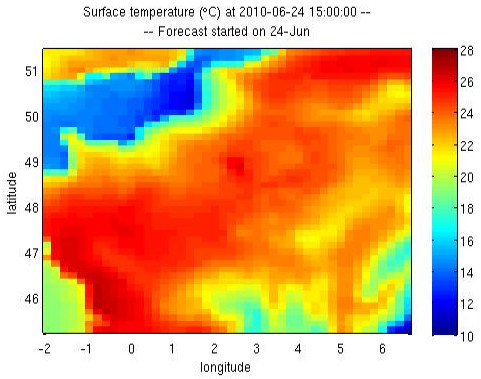

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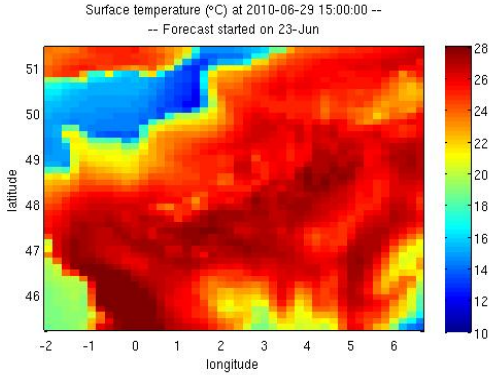
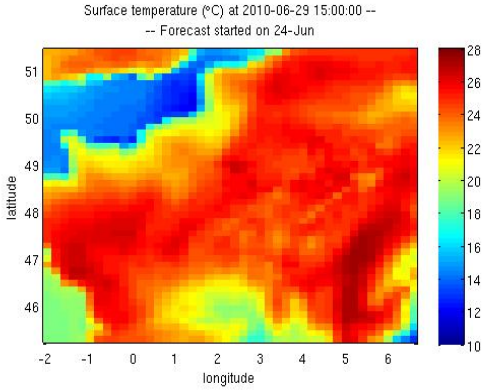
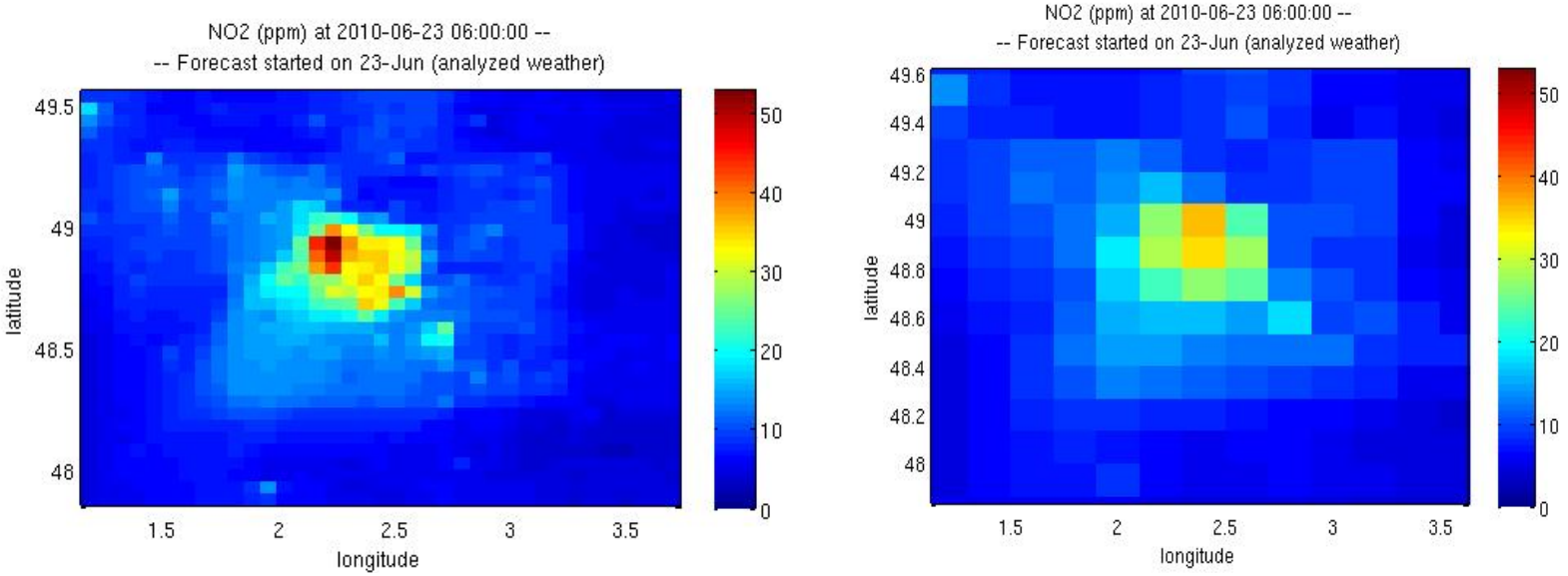
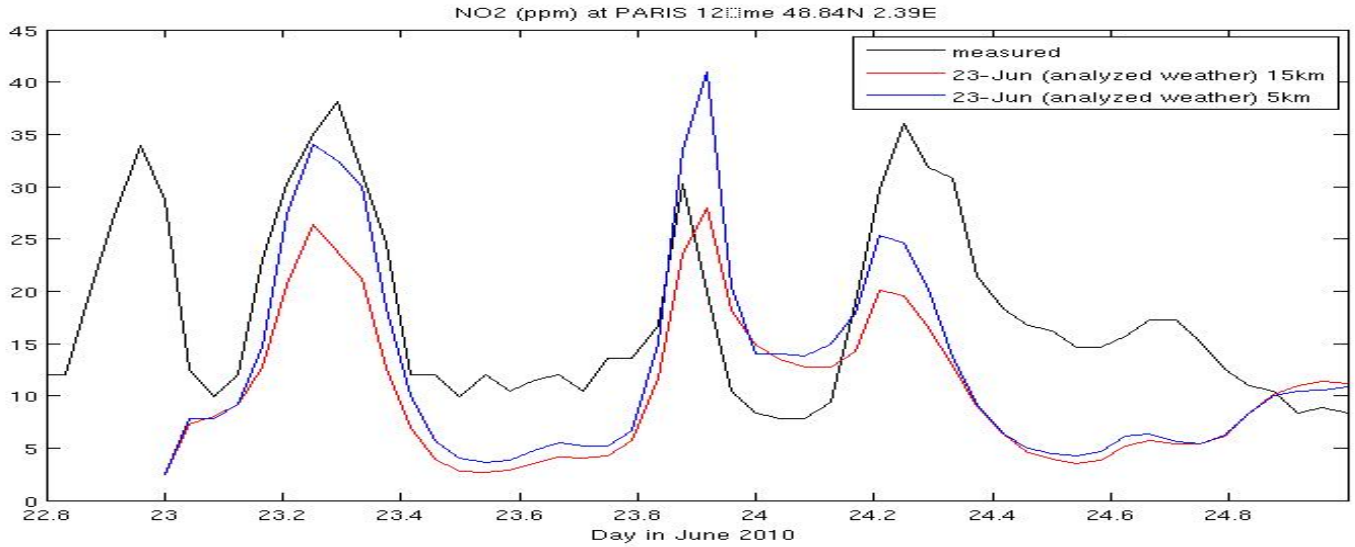


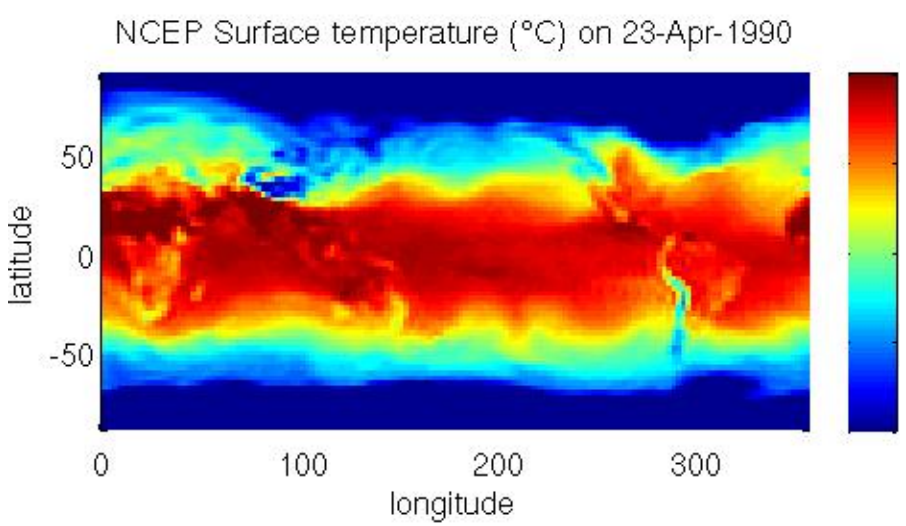


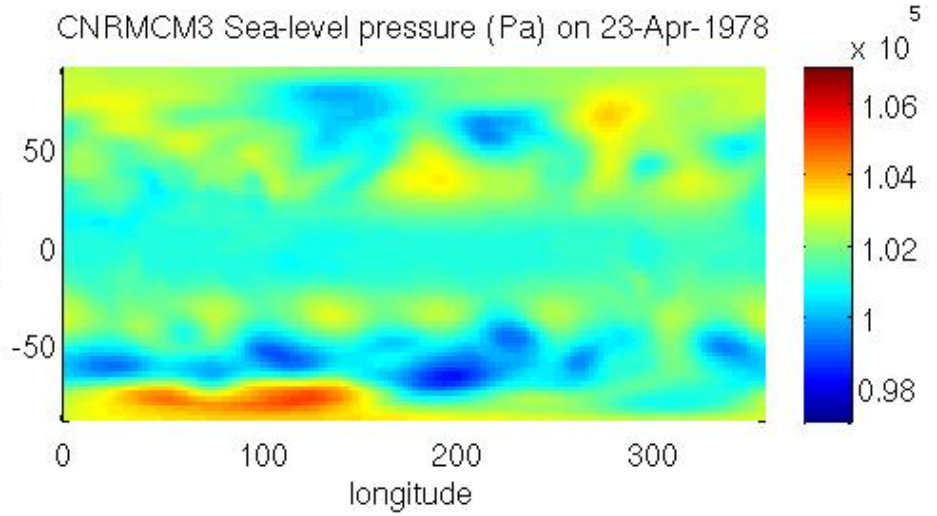
How resolution affects modelled concentrations

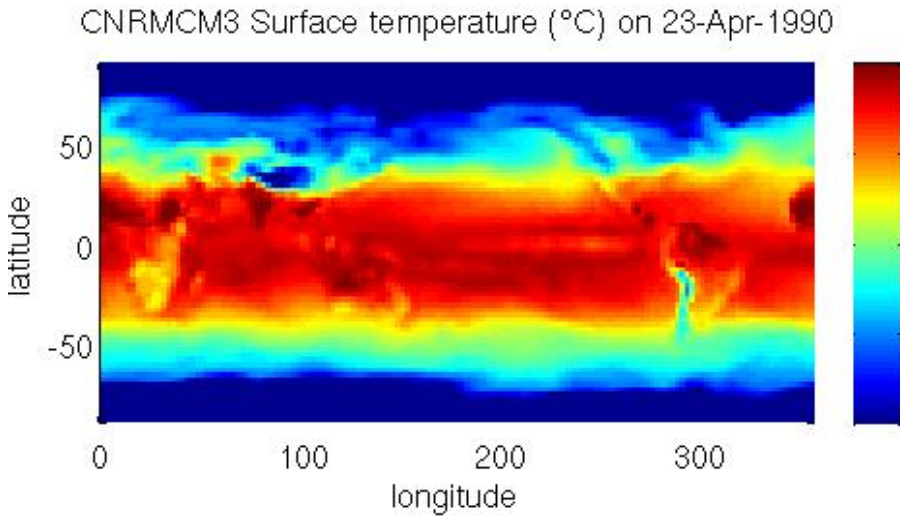


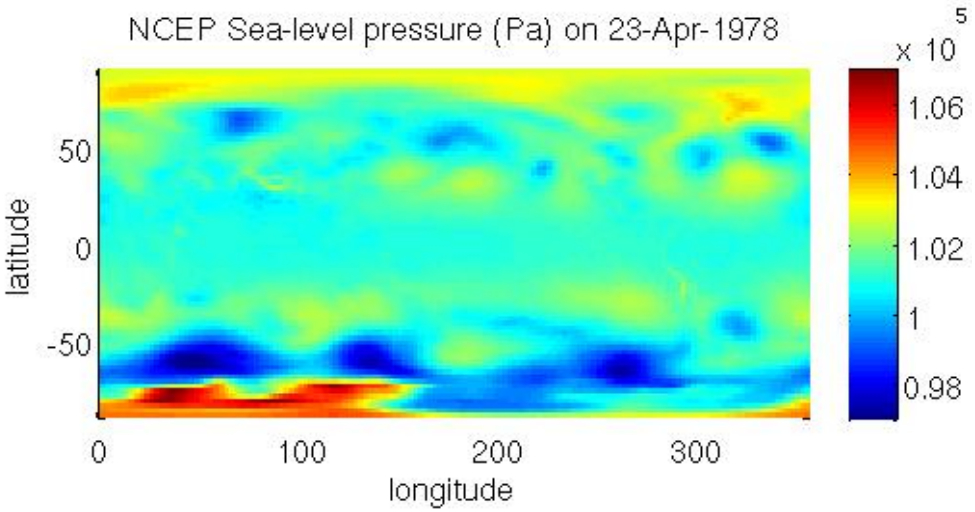


Surface Temperature and Pressure Maps

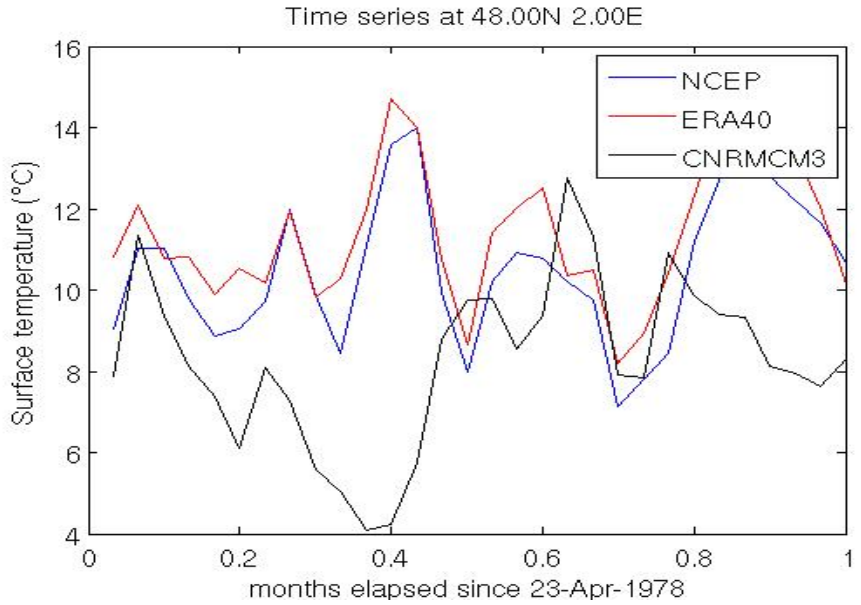




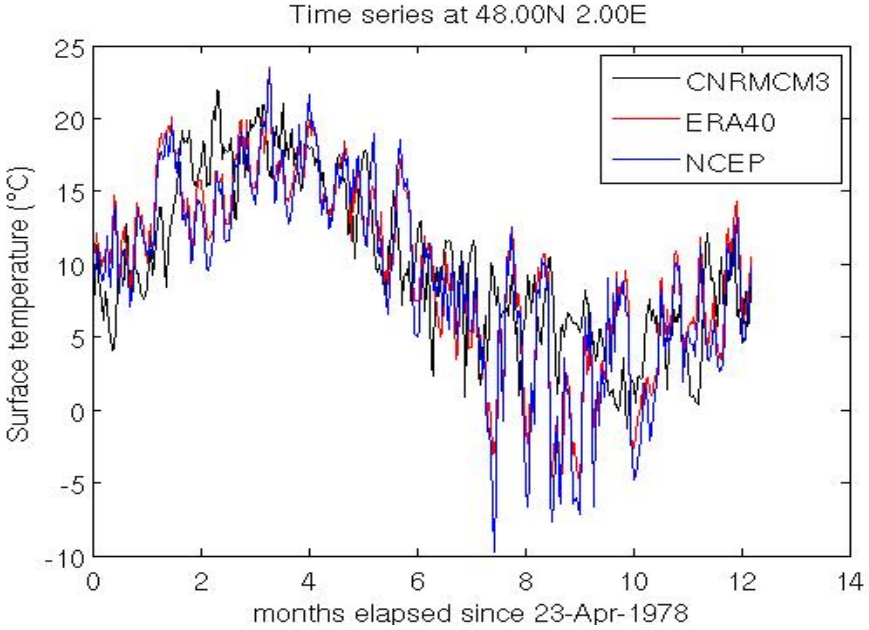


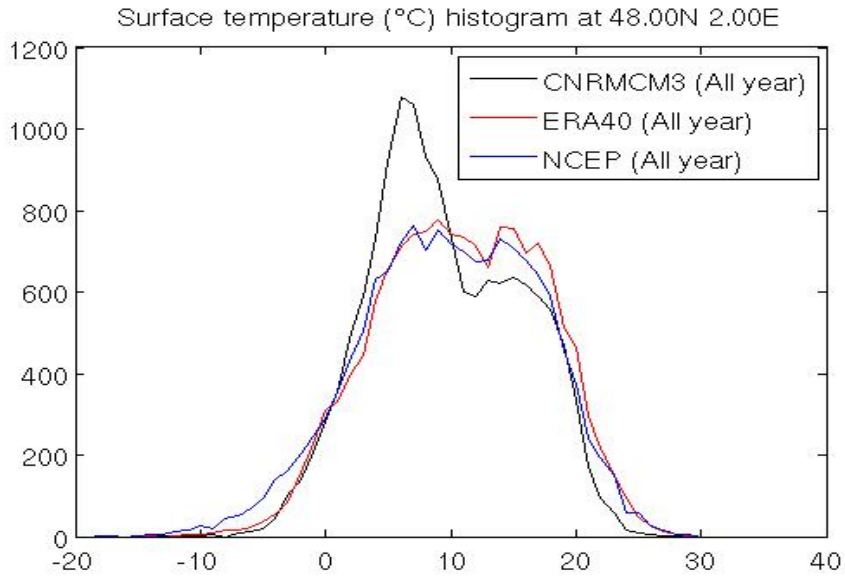


Comparison of Results



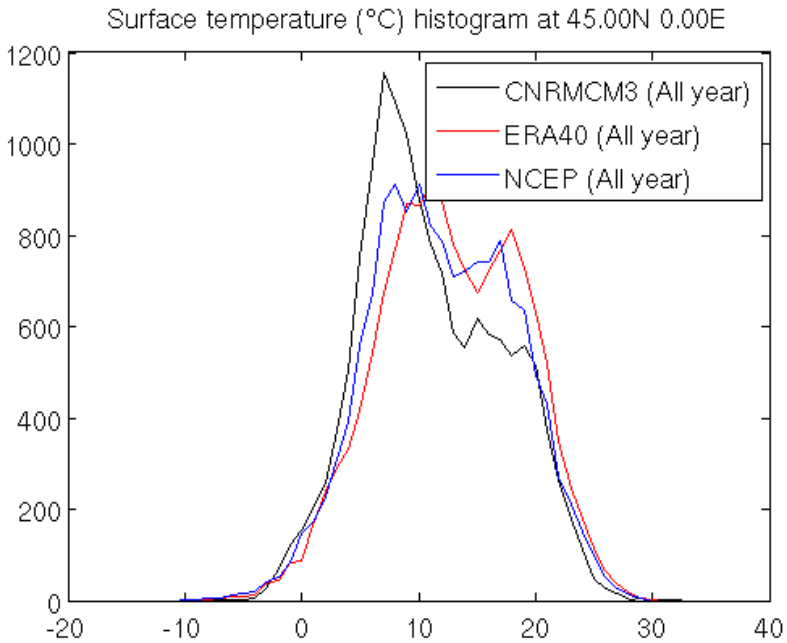
Location chosen: Paris
Time series: 1 month and 1 year
Histograms: 40 years

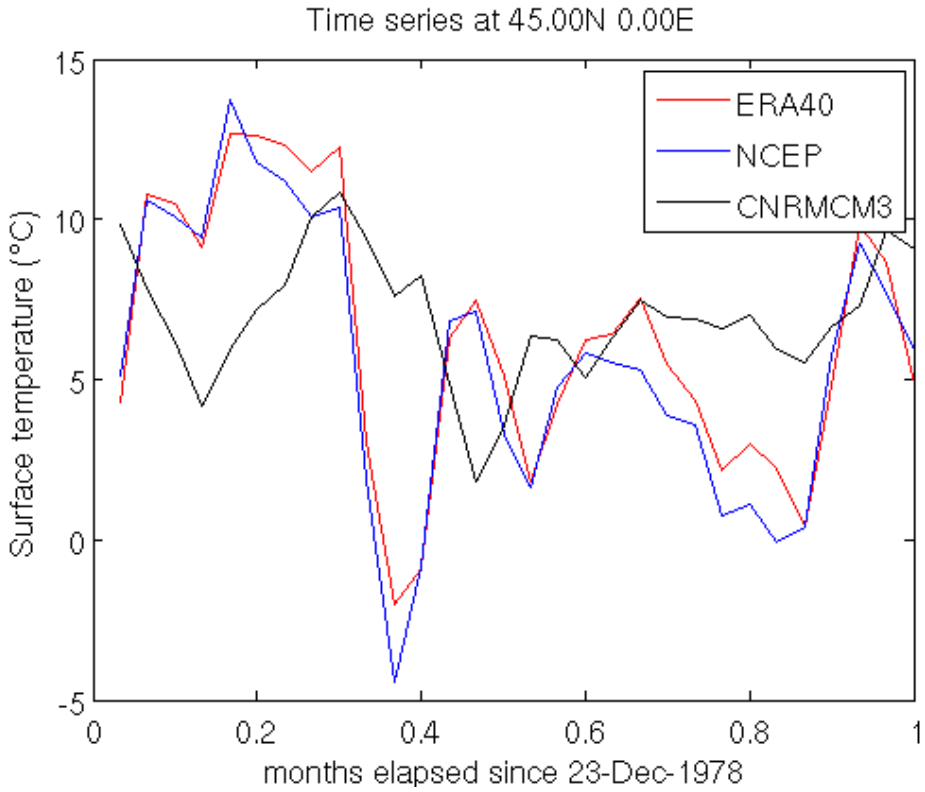




Climate models and weather models

- Weather models slightly differ due to errors in source data (satellite resolution, clouds, health of equipment), errors in the model and a lack of constraints
- Weather models differ to climate models due to different addressed purpose





- Weather models are supposed to be precise on a timely and regional basis
- Climate models show global trends and are precise in terms of distribution of values

General conclusion

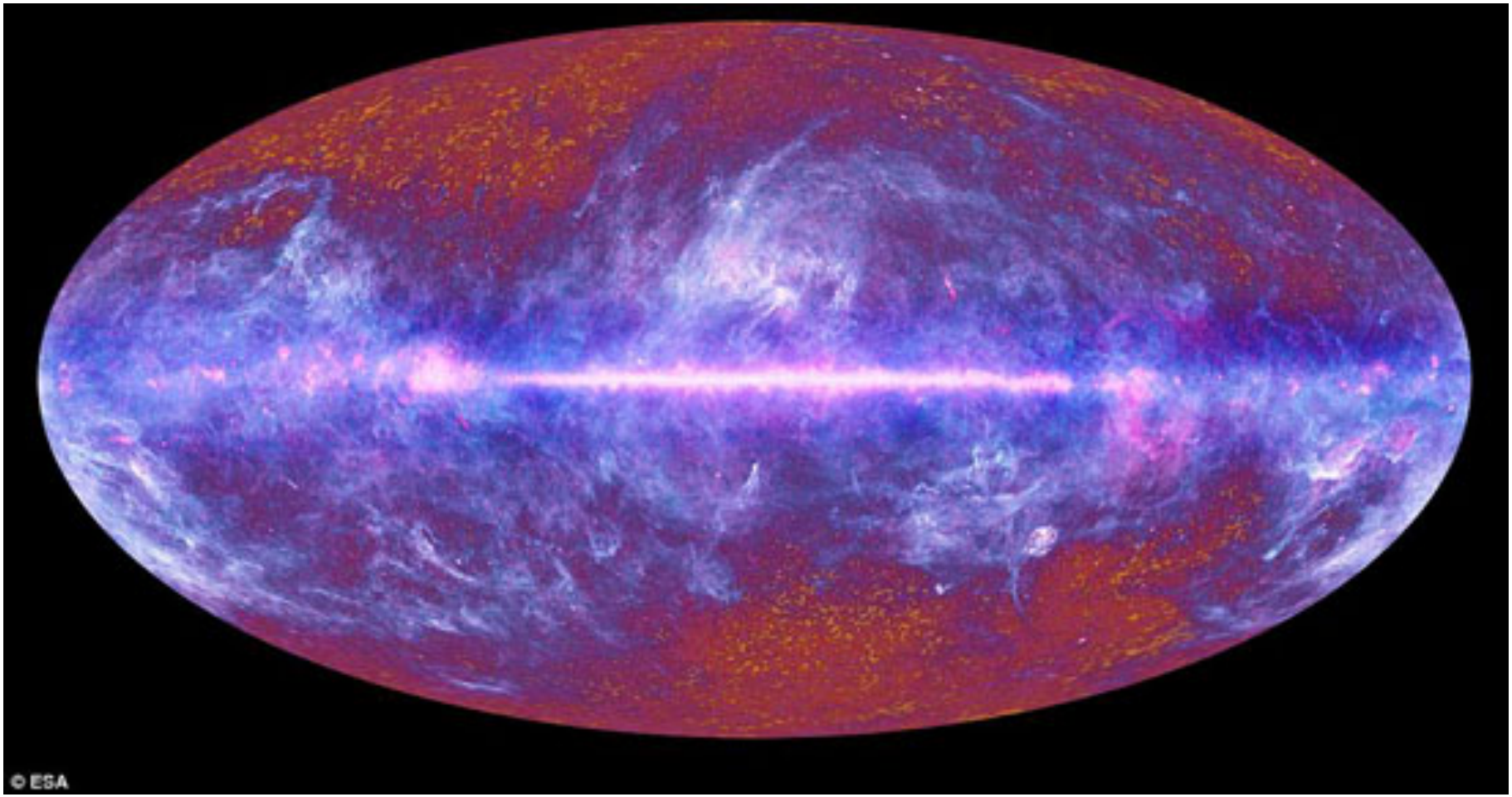
Alternative applications

- Military
- Public Safety
- Public Health
- Aviation
- Agriculture

Industrial implications

- Preemptive understanding of data (legal implications)

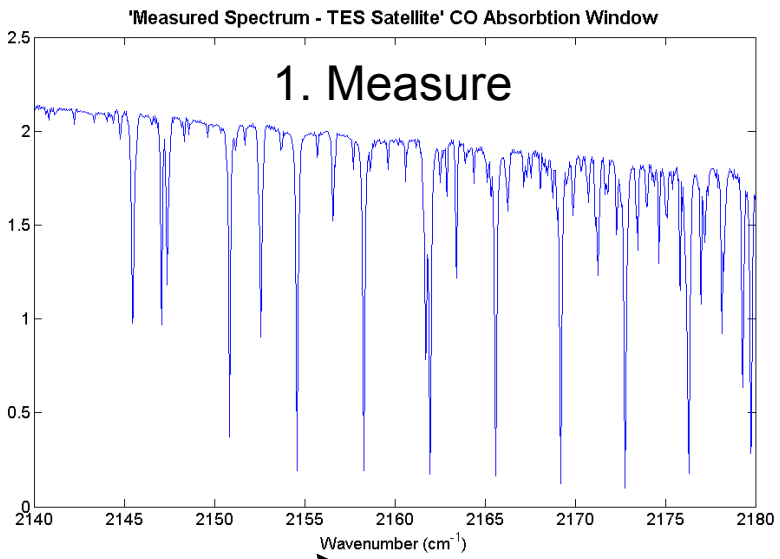
We are not only modelling the Earth…..

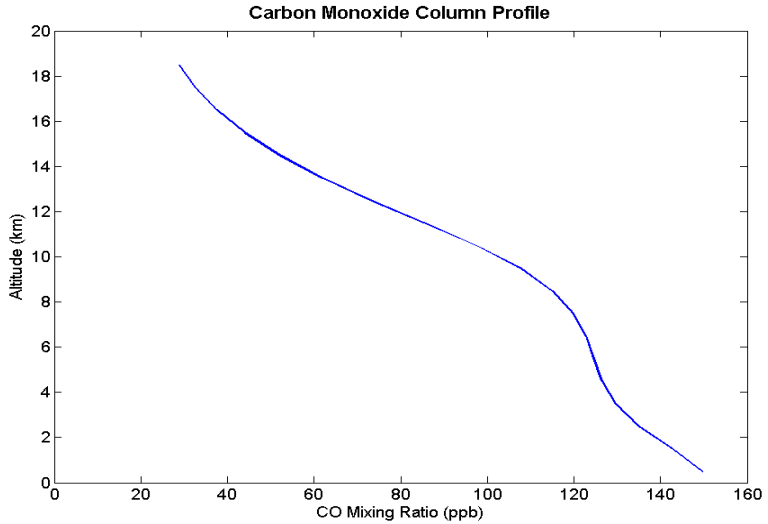


Source: European Space Agency

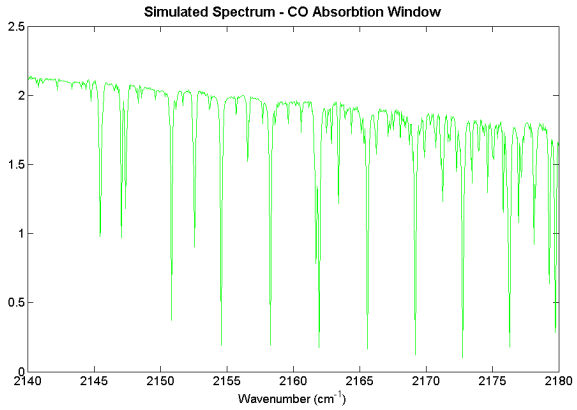
THANK YOU!

Results of the Observing System Simulation Experiment Results (3/4)





2. Simulation



3. Compare

From simulations to reality: IASI/METOP CO retrievals